Data carrier with modification means for modifying the load period

The invention relates to a data carrier for contactless communication with a
base station by means of an electromagnetic field generated by the base station, having an
antenna coil connected to a first coil terminal and to a second coil terminal, in which antenna
coil an antenna signal can be induced in operation by the electromagnetic field, and having
5   modulation means for modulating the electromagnetic field, during successive load periods
and off-load periods, with transmission data to be communicated to the base station, the
electromagnetic field being load-modulated during the load periods by modifying the value
of the impedance of a modulation load that is connected at least indirectly to the first coil
terminal and the second coil terminal.

10   The invention further relates to an integrated circuit of a data carrier for
contactless communication with a base station by means of an electromagnetic field
generated by the base station, having a first coil terminal and a second coil terminal, to which
an antenna coil can be connected, in which antenna coil an antenna signal can be induced in
operation by the electromagnetic field, and having modulation means for modulating the
15   electromagnetic field, during successive load periods and off-load periods, with transmission
data to be communicated to the base station, the electromagnetic field being load-modulated
during the load periods by modifying the value of the impedance of a modulation load that is
connected at least indirectly to the first coil terminal and the second coil terminal.

The invention further relates to a method of modulation for the modulation, by
20   a data carrier, of an electromagnetic field generated by a base station, wherein the following
steps are carried out:

modulation of the electromagnetic field by the data carrier, during successive
load periods and off-load periods, with transmission data to be communicated to the base
station, the electromagnetic field being load-modulated during the load periods by modifying
25   the value of the impedance of a modulation load belonging to the data carrier.

A data carrier of this kind, an integrated circuit of this kind and a method of
modulation of this kind are known from document EP 0 669 591 B. This document discloses
a data carrier that is designed for contactless communication with a base station. Data carriers
of this kind are contained, for example, in so-called smart cards and are designed to

communicate transmission data to the base station by means of an electromagnetic field of, for example, 13.56 MHz that is emitted from the base station. The known data carrier has an antenna coil, connected to a first and a second coil terminal, for receiving the electromagnetic field and for emitting a coil voltage arising in the antenna coil as an antenna signal for the

5   data carrier. To modulate the electromagnetic field, the known data carrier has modulation means that load the electromagnetic field with a modulation load during the duration of a load period and that unload it again during the duration of a succeeding off-load period.

     The base station has an antenna coil for receiving the load-modulated electromagnetic field and for emitting a coil voltage that arises in the antenna coil as an

10   antenna signal in the base station. During the load period, the envelope of the antenna signal falls to a load voltage and during the off-load period it rises again to an off-load voltage. This rise and fall in the envelope of the antenna signal in the base station is analyzed in the base station to allow the transmission data to be received (amplitude or phase modulation).

     It has been found that the distance of the data carrier from the base station has

15   an effect on the speed of the rise and fall of the envelope of the antenna signal in the base station during the load period and off-load period. The known data carrier does not make any allowance for this effect, for which reason the base station is not able to determine the transmission data to optimum effect by analyzing the antenna signal.

     It is an object of the invention to provide a data carrier of the kind specified in

20   the first paragraph, an integrated circuit of the kind specified in the second paragraph, and a method of modulation of the kind specified in the third paragraph, in which the disadvantages detailed above are avoided. To achieve the object specified above, a data carrier of the above kind has the following further features:

     detection means for detecting an item of energy information that characterizes

25   the energy contact of the antenna signal, and

     comparator means for comparing the item of energy information detected with a preset item of energy information and for emitting an item of comparison information, and

     modification means for modifying the ratio of the duration of the load period to the duration of the succeeding off-load period as a function of the item of comparison

30   information.

     To achieve the object specified above, an integrated circuit of the above kind has the following further features:

     detection means for detecting an item of energy information that characterizes the energy content of the antenna signal, and

comparator means for comparing the item of energy information detected with
a preset item of energy information and for emitting an item of comparison information, and

modification means for modifying the ratio of the duration of the load period
to the duration of the succeeding off-load period as a function of the item of comparison
information.

To achieve the object specified above, the following further method steps are
provided in a method of modulation of the above kind:

determination of the distance between the data carrier and the base station,

adjustment of the ratio of the duration of the load period to the duration of the
succeeding off-load period as a function of the distance determined between the data carrier
and the base station.

What is achieved by the features according to the invention is that the ratio of
the duration of the load period to the duration of the off-load period is modified in the data
carrier in line with the distance to the base station in such a way that the base station is able
to analyze the antenna signal in the base station to optimum effect. If, for example, the data
carrier is positioned relatively far away from the base station, then the case occurs that the
envelope of the antenna signal in the base station falls relatively quickly to the load voltage
as from the beginning of the load period, but rises again only relatively slowly as from the
beginning of the off-load period. If in this case the off-load period is too short for the
envelope of the antenna signal in the base station to rise from the load voltage to the off-load
voltage within the full length of the off-load period, then the transmission data cannot be
analyzed reliably in the base station. When this is the case, the modification means according
to the invention make the ratio of the duration of the load period to the duration of the off-
load period smaller by lengthening the duration of the off-load period, as a result of which
the analysis of the envelope of the antenna signal in the base station to allow the transmission
data to be determined can be substantially improved.

Something that is particularly advantageous in this case is that the
modification means provided in the data carrier adjust the data carrier to the distance at
which the data carrier is situated from the base station to make it possible for the transmission
data to be received optimally in the base station. An adjustment in the base station can take
place, but it does not have to.

By the provisions dealt with in claims 4, 10 and 16, the advantage is obtained
that the modulation means of the data carrier perform a subcarrier modulation and the
modification means are designed to modify the mark-to-space ratio of the subcarrier signal.

In this way, the sum of the duration of the load period and the duration of the off-load period can be kept constant for encoding the transmission data and the adjustment of the data carrier to the distance from the base station is performed solely by modifying the mark-to-space ratio of the subcarrier signal.

5   By the provisions dealt with in claims 5, 6, 11 and 12, it becomes possible for detection means for determining the energy content of the antenna signal to be implemented in a reliable way.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter, though it is not to be

10   considered as limited to these.

In the drawings:

Fig. 1 shows a data carrier having modification means, for contactless

15   communication with a base station.

Fig. 2 shows the waveform over time of transmission data that is transmitted from the data carrier to the base station.

Fig. 3 shows the waveform over time of the transmission data when coded by the Manchester coding method.

20   Fig. 4 shows the waveform over time of a subcarrier-modulated transmission signal that arises in the data carrier.

Fig. 5 shows the waveform over time of the electromagnetic field that, having been load-modulated with the signal shown in Fig. 4, is induced in the antenna coil of the base station, an idealized signal waveform having been assumed.

25   Fig. 6 shows the actual waveform over time of the antenna signal that is received from the electromagnetic field by the base station, when a prior-art data carrier is positioned within the reception zone of the base station, but relatively far away from the latter, and transmits transmission data.

Fig. 7 shows the actual waveform over time of the antenna signal that is

30   received from the electromagnetic field by the base station, when the prior-art data carrier is positioned within the reception zone of the base station, but relatively close to the latter, and transmits transmission data.

Fig. 8 shows the actual waveform over time of the antenna signal that is received from the electromagnetic field by the base station, when the data carrier according

to the invention as shown in Fig. 1 is positioned within the reception zone of the base station, but relatively far away from the latter, and transmits transmission data.

5   Fig. 9 shows the actual waveform over time of the antenna signal that is received from the electromagnetic field by the base station, when the data carrier according to the invention as shown in Fig. 1 is positioned within the reception zone of the base station, but relatively close to the latter, and transmits transmission data.

          Fig. 1 shows a data carrier 1 that is formed by an integrated circuit 2 and an
10   antenna coil 3 and that is designed for contactless communication with a base station 4 by means of an electromagnetic field HF that is generated by the base station 4. The antenna coil 3 is connected to a first coil terminal 5 and a second terminal 6 of the integrated circuit 2, an antenna signal ASD being induced in the antenna coil 3 of the data carrier 1 in operation and an antenna signal ASB in the antenna coil of the base station 4.

15   The antenna signal ASD can be fed to supply voltage means 7 of the data carrier 1, which rectify the antenna signal ASD and emit a supply voltage UV for all the other means and stages of the data carrier 1. The supply voltage UV is limited by a regulator stage 8 that bleeds off a parallel regulator current IR if the distance from the data carrier 1 to the base station 4 is relatively short and if the energy content of the antenna signal ASD induced
20   in the antenna coil 3 is too high for the data carrier 1. The regulator stage 8 is designed to emit an item of regulator-current information IRI that is a function of the size of the parallel regulator current IR and thus characterizes the distance at which the data carrier 1 is situated from the base station 4.

          The antenna signal ASD can also be fed to clock-signal generating means 9 of
25   the data carrier, which derive from the clock frequency of the antenna signal ASD a clock signal for the data carrier 1 and transmit it to processor means 10 and subcarrier generating means 11 of the data carrier 1.

          The antenna signal ASD can also be fed to a demodulator 12 of the data carrier 1, which demodulates the transmission data UDB contained in the antenna signal ASD that is
30   being transmitted from the base station 4 to the data carrier 1. In this connection, the man skilled in the art will be familiar with a large number of types of modulation and demodulation and this question will therefore not be considered in detail here. The antenna signal demodulated by the demodulator 12 can be fed to decoding means 13 of the data carrier 1. In this connection, the man skilled in the art will be familiar with a large number of

types of encoding and decoding and this question will therefore not be considered in detail here. The transmission data UDB determined by the decoding means 13 can be transmitted to the processor means 10. The processor means 10 are designed to process the received transmission data UDB and to store the received or processed transmission data UDB in
5   storage means S.

If transmission data UDD is to be transmitted from the data carrier 1 to the base station 4, then the transmission data UDD can be transmitted by the processor means 10 to encoding means 14. Transmission data UDD of this kind is shown in Fig.2 in the form of a bit sequence "0101100" and the corresponding voltage waveform over time. The encoding
10 means 14 are designed to encode the transmission data UDD by the Manchester encoding method and they transmit encoded transmission data KUDD to a demodulator 15 of the data carrier 1. Encoded transmission data KUDD is shown in Fig. 3.

The modulator 15 is designed to modulate the electromagnetic field HF during successive load periods TB and off-load periods TE with encoded transmission data KUDD
15 that is to be communicated to the base station 4, the electromagnetic field HF being load modulated during the load periods TB by a modification in the value of the impedance of a modulation load that is connected at least indirectly to the first coil terminal 5 and the second coil terminal 6. For this purpose, the modulator first performs a subcarrier modulation of the encoded transmission data KUDD with a subcarrier signal HTS that is emitted by the
20 subcarrier generating means 11. A subcarrier-modulated transmission signal of this kind HUS is shown in Fig. 4.

To continue the sequence, the modulator 15 is designed to connect an impedance between the first coil terminal 5 and the second coil terminal 6 during high periods of the subcarrier-modulated transmission signal HUS (load periods TB) and in so
25 doing to load the electromagnetic field HF with this impedance and thus to perform load modulation. During low periods of the subcarrier-modulated transmission signal HUS (off-load periods TB), the impedance is switched away from the first antenna terminal 5 and in this way the load is removed from the electromagnetic field HF, as a result of which the electromagnetic field HF is load-modulated. The antenna signal ASB that is induced in the
30 antenna coil of the base station 4 by the load-modulated electromagnetic field HF is shown in Fig. 5.

The signal waveforms shown in Figs. 4 and 5 are idealized signal waveforms that in practice are modified by loading and unloading processes in the antenna coil 3 and the antenna coil of the base station 4 and by other effects familiar to the man skilled in the art. In

Figs. 6 to 9 are shown waveforms of the antenna signal ASB that occur in practice in the
antenna coil of the base station, the time interval Z1 being shown in an enlarged form in Figs.
6 to 9.

The waveform of the antenna signal ASB that is shown in Fig. 6 shows a fast
5   unloading process during the load period TB and a slow loading process during the off-load
period TE. What is meant by unloading process in this case is the decay of oscillation in the
antenna oscillator circuit and what is meant by a loading process is the rise to settled
oscillation of the antenna oscillator circuit of the data carrier 1. If the electromagnetic field
HF is not loaded by any data carrier situated within communication range of the base station
10   4, then an off-load voltage UE is set up. If such a data carrier then loads the electromagnetic
field HF, the antenna signal ASB falls relatively quickly to the load voltage UB during the
first load period TB. From the beginning of the off-load period TE, when the data carrier is
no longer loading the electromagnetic field HF, the antenna signal ASB rises relatively
slowly and, by the time the electromagnetic field HF is again loaded by the data carrier
15   during the next load period TB, has reached only an intermediate voltage UZ. Only after the
last load period TB in a series of successive load periods TB and off-load periods TE does
the antenna signal again rise to the off-load voltage UE.

The waveform of the antenna signal ASB that has been described above and is
shown in Fig. 6 occurs when a prior-art data carrier is positioned within communication
20   range of the base station 4 but relatively far away from the base station 4. In Fig. 7 the
opposite case in shown, where the prior-art data carrier is positioned relatively close to the
base station 4. In Fig. 7 the antenna signal ASB falls relatively slowly during the load period
TB only to the intermediate voltage UZ and during the off-load period TE it rises relatively
quickly to the off-load voltage UE. In the base station 4, it is difficult for such different
25   antenna signals ASB, from prior-art data carriers that are positioned relatively close to, and
relatively far from, the base station 4, to be decoded, for which reason there is a relatively
high error rate in the transmission data UDD.

The data carrier 1 according to the invention therefore has detection means 16
that are designed to detect an item of energy information EI that characterizes the energy
30   content of the antenna signal ASD. Regulator means 8 as described above form the detection
means 16 and the item of regulator-current information IRI emitted by the regulator means 8
characterizes the energy content of the antenna signal ASD. The data carrier 1 has in addition
antenna voltage means 17 that determine the antenna voltage US applied to the coil terminals
5 and 6. The antenna voltage US likewise characterizes the energy content of the antenna

signal ASD and a corresponding item of energy information EI can be transmitted by the
antenna voltage means 17 to comparator means 18 of the data carrier 1.

The comparator means 18 then compare the item of regulator-current
information IRI with one or more items of threshold regulator-current information stored in
5   the data carrier 1 and/or compare the antenna voltage US with one or more items of threshold
antenna-voltage information stored in the data carrier 1. The result or results of the
comparison give the distance at which the data carrier 1 is situated from the base station 4,
whereupon an item of comparison information VI giving this information is transmitted to
modification means 19 in the data carrier 1.

10   The modification means 16 are then designed to modify the ratio of the
duration of the load period TB to the duration of the succeeding off-load period TE as a
function of the item of comparison information VI. An item of ratio information RI that gives
the optimum ratio of the load period TB to the off-load period TE as a function of the
distance at which the data carrier 1 is situated from the base station 4 can be transmitted by
15   the modification means 19 to the modulator 15. The sum of the duration of the load period
TB and the succeeding off-load period TE is always equal in this case to the length of one
cycle of the subcarrier signal HTS.

Fig. 8 then shows the waveform of the antenna signal ASB when it is the data
carrier 1 according to the invention that modulates the electromagnetic field HF. Even
20   though, in this case too, the data carrier 1 is again positioned relatively far away from the
base station 4 in the communication zone (fast fall and slow rise of the antenna signal ASB),
the antenna signal ASB that is received in the base station 4 reaches the load voltage UB
during every load period TB, and the off-load voltage UE during every off-load period TE.
As a result, a demodulator at the base station 4 is able to demodulate the antenna signal ASB
25   shown in Fig. 8 particularly well, and for this reason there is a relatively low error rate when
transmission data UDD is transmitted.

In Fig. 9 is shown the waveform of the antenna signal ASB when the data
carrier according to the invention is positioned relatively close to the base station 4. In this
case, the load periods TB preset by the modification means 19 are considerably longer than in
30   Fig. 8 and for this reason the load voltage UB is reached during every load period TB and the
off-load voltage UE is reached during every off-load period TE, even when the data carrier 1
according to the invention is so positioned in the communication zone. The demodulator at
the base station 4 is therefore able to demodulate the antenna signal ASB particularly well in
this case too.

It is particularly advantageous if the comparator means 18 and the modification means 19 are so designed that the ratio of the duration of the load period TB to the duration of the off-load period TE is steplessly variable. In this way, the ratio of the periods TB and TE will be optimally adjusted to any distance at which the data carrier 1 may

5 be situated from the base station 4.

It may be mentioned that, if load modulation without subcarrier modulation is used, it is also possible for the ratio of the durations of the high periods and low periods of the encoded transmission data KUDD or of the transmission data UDD to be modified as a function of the comparison information and thus as a function of the distance at which the

10 data carrier is situated from the base station. The ratio of the high and low periods would, once again, be modified in such a way that the duration of a complete cycle (high period + low period) remained constant for a "1" or "0" bit or for an encoded "1" or "0" bit. In this way a constant data rate and other advantages according to the invention that were mentioned above are obtained.

15 It may be mentioned that detection means of a data carrier according to the invention may also be formed only by the regulator means 8 or only by antenna voltage means 17 or only by comparable means.

It may be mentioned that a data carrier according to the invention does not have to have any clock-signal generating means because the clock signal for the data carrier

20 could also be generated by an oscillator belonging to the processor means.

It may be mentioned that a data carrier according to the invention does not have to include a demodulator because a data carrier that is not asked to transmit by the base station (tag talks first) can send transmission data to the base station as soon as the supply voltage means had obtained sufficient energy from the electromagnetic field.

25 It may be mentioned that in the present connection the term antenna coil should also be understood to mean what is termed a dipole antenna, which is formed by two short stubs of wire.

It may be mentioned that the modulation load does not have to be connected directly to the antenna terminals but may for example be arranged in the data carrier

30 downstream of the supply voltage means 7 at the position occupied by the regulator means 8.

It may be mentioned that the distance between the data carrier and the base station could also be determined by the base station and communicated to the data carrier.

It may be mentioned that the impedance of the modulation means could be purely inductive, capacitive or resistive or a mixture of these.

It may be mentioned that the modification of the ratio of the duration of the load period to the duration of the off-load period may be performed by lengthening or shortening the load period and/or the off-load period.

It may be mentioned that the energy content of the antenna signal is affected by the distance at which the data carrier is situated from the base station but also by the degree of coupling of the antenna oscillator circuit of the data carrier to the antenna oscillator circuit of the base station. The disclosure is therefore to be understood to the effect that, whenever a short distance from the data carrier to the base station is described, what is also meant is high coupling between the oscillator circuits. In the opposite case, when a long distance between the data carrier and the base station is described, what is also always meant is low coupling between the antenna oscillator circuits.